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(19) (CA) **CANADIAN PATENT** (12)

(54) Production of 2-(2-Pyridylmethylsulfinyl)Benzimidazole Compounds

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Abstract of the disclosure

2-(2-pyridylmethylsulfinyl)benzimidazole compounds are produced by subjecting 2-(2-pyridylmethylthio)benzimidazole compounds to oxidation with hydrogen peroxide in the presence of vanadium compounds in good yield and with low production of by-products.

1 Production of 2-(2-Pyridylmethylsulfinyl)benzimidazole
 Compounds

5 This invention relates to the production of 2-(2-pyridylmethylsulfinyl)benzimidazole compounds (refer to, for example, U.S. Patent No.4255431, European Patent Laid-Open No.45200, No.74341, No.80602, No.5129, No.174726, No.175464, British Patent Laid-Open No.2134523A), which are useful as antiulcer agents.

10 As a method for production of 2-(2-pyridylmethylsulfinyl)benzimidazole compounds, an oxidation of the corresponding 2-(2-pyridylmethylthio)benzimidazole compounds with m-chloroperbenzoic acid is mentioned (refer to, for example, U.S. Patent No.4255431, European Patent
15 Laid-Open No.80602).

 Generally known methods for production of sulfoxides from sulfides include oxidation with peracid, hydrogen peroxide, iodosobenzene, N-halosuccinimide, tertiary butyl hypochloride, sodium metaperiodate, selenium dioxide,
20 bromine, chlorine, or ozone [Refer to: Saul Patai, The chemistry of ethers, crown ethers, hydroxyl groups and their sulphur analogues, Supplement E, Part 1, p.539-608, John Willey & Sons, An Interscience Publication (1980), Michel Madesclaire, Tetrahedron Report Number 210, "Syn-
25 thesis of Sulfoxides by Oxidation of Thioethers", Tetrahedron, 42, 5459-5495 (1986)].

 However, the specifications or references do not include concrete examples of practical production of 2-(2-pyridylmethylsulfinyl)benzimidazole compounds by oxidation with hydrogen peroxide as the
30 oxidizing agent.

 Oxidation of 2-(2-pyridylmethylthio)benzimidazole compounds with m-chloroperbenzoic acid gives 2-(2-pyridylmethylsulfinyl)benzimidazole compounds only in low yields,
35 producing much side products such as 2-(2-pyridylmethyl-

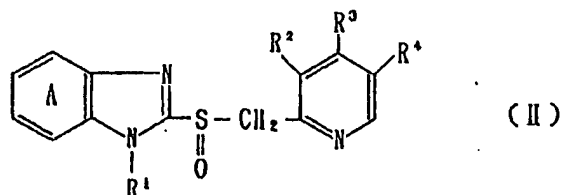


1 sulfonyl)benzimidazole N-oxide. Such side products are
very difficult to remove from 2-(2-pyridylmethylsul-
finyl)benzimidazole compounds with usual methods of puri-
fication, such as recrystallization. Expensiveness of m-
5 chloroperbenzoic acid is an additional problem.

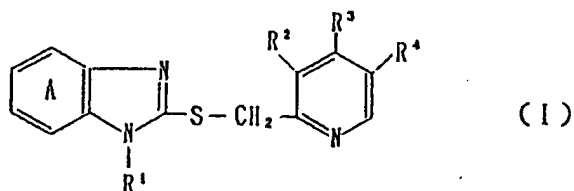
There are some problems in oxidation of 2-(2-pyridyl-
methylthio)benzimidazole compounds with one of the oxi-
dizing agents described above other than hydrogen per-
oxide; the reaction will not proceed in many cases, and
10 the yield is very low (less than about 75%) because of
degradation or production of a great amount of by-products.

As the results of the inventors' researches to find a
method for production of 2-(2-pyridylmethylsulfinyl)benz-
15 imidazole compounds from 2-(2-pyridylmethylthio)benzimidazole
compounds in good yield and with low production of
by-products such as 2-(2-pyridylmethylsulfonyl)benz-
imidazole N-oxides, the inventors have found that oxidation
with hydrogen peroxide in the presence of vanadium com-
20 pounds, for example, vanadium oxides or vanadium salts, as
the catalyst accomplishes the purpose, and have completed the
invention after further researches.

This invention relates to a method for
producing a compound having the formula (II):



wherein the ring A may be substituted; R¹ is a hydrogen
atom or an N-protective group; R², R³ and R⁴ are
independently hydrogen atom, an alkyl group which
may be fluorinated or an alkoxy group which may be fluorinated,
35 which comprises subjecting a compound having the
formula (I):



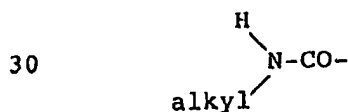
wherein A, R¹, R², R³ and R⁴ are the same as described above, to oxidation with hydrogen peroxide in the presence of vanadium compounds.

- 10 In compounds (I) and (II), the substituents in the ring A include alkyl, halogen, cyano, carboxy, carboalkoxy, carboalkoxyalkyl, carbamoyl, carbamoylalkyl, hydroxy, alkoxy, hydroxyalkyl, trifluoromethyl, acyl, carbamoyloxy, nitro, acyloxy, aryl, aryloxy, alkylthio and alkylsulfi-
- 15 nyl etc. The alkyl groups are desirably those having 1 to 7 carbon atoms, including methyl, ethyl, propyl, isopropyl, butyl, isobutyl, pentyl, hexyl and heptyl etc. The halogen atoms include fluorine, chlorine and bromine atoms, among which the fluorine atom is the most desirable.
- 20 The carboalkoxy groups are desirably those in which the alkoxy group has 1 to 4 carbon atoms, including carbo-methoxy (CH₃OOC-) and carboethoxy (C₂H₅OOC-) etc. The carboalkoxyalkyl groups are desirably those in which the alkoxy and alkyl groups have 1 to 4 carbon atoms each,
- 25 including carbomethoxymethyl (CH₃OOCCH₂-), carbomethoxyethyl (CH₃OOCCH₂CH₂-), carboethoxymethyl (C₂H₅OOCCH₂-) and carboethoxyethyl (C₂H₅OOCCH₂CH₂-) etc. The carbamoylalkyl groups are desirably those in which the alkyl group has 1 to 4 carbon atoms, including carbamoylmethyl (H₂NCOCH₂-) and
- 30 carbamoylethyl (H₂NCOCH₂CH₂-) etc. The alkoxy groups are desirably those having 1 to 5 carbon atoms, including methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy and pentoxy etc. The hydroxyalkyl groups are desirably
- 35 those in which the alkyl group has 1 to 7 carbon atoms, including hydroxymethyl and 1-hydroxy-propyl-2,1-hydroxyethyl-2,1-hydroxy-2-methyl-propyl-2 etc. The acyl

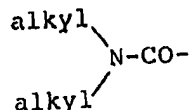
1 groups are desirably those having 1 to 4 carbon atoms,
including formyl, acetyl, propionyl, butyl and isobutyl-
2 etc. The acyloxy groups are desirably those in
which the acyl group has 1 to 4 carbon atoms, including for-
5 myloxy, acetyloxy, propionyloxy, butyloxy, and iso-
butyloxy etc. The aryl groups include phenyl, tolyl
and naphthyl etc. The aryloxy groups include phenoxy,
6 tolyloxy and naphthyloxy etc. The alkylthio groups are
desirably those in which the alkyl group has 1 to 4 carbon
10 atoms, including methylthio, ethylthio and propylthio etc.
The alkylsulfinyl groups are desirably those having 1
to 6 carbon atoms, including methylsulfinyl, ethylsulfi-
nyl and propylsulfinyl etc.

The ring A is not substituted or is substituted at
15 the 4- or 5-position particularly desirably with alkyl,
halogen, trifluoromethyl or alkoxy among the substituents
described above.

The N-protective groups represented by R^1 include
alkyl, acyl, carboalkoxy, carbamoyl, alkylcarbamoyl,
20 dialkylcarbamoyl, alkylcarbonylmethyl, alkoxycarbonyl-
methyl and alkylsulfonyl etc. The alkyl groups are
desirably those having 1 to 5 carbon atoms, including
methyl, ethyl, propyl, isopropyl, butyl, isobutyl and
pentyl etc. The acyl groups include the same groups as
25 those described for the substituents of the ring A. The
carboalkoxy groups include the same groups as those
described for the substituents of the ring A. The
alkylcarbamoyl groups are represented by the formula:



wherein the alkyl group has desirably 1 to 4 carbon atoms,
including methylcarbamoyl, ethylcarbamoyl, propylcarba-
moyl and isopropylcarbamoyl etc. The dialkylcarbamoyl
35 groups are represented by the formula:



- 1 wherein the alkyl groups have desirably 1 to 4 carbon
atoms each, including dimethylcarbamoyl, diethylcarbamoyl
and N-methyl-N-ethylcarbamoyl etc. The alkylcarbonyl-
methyl groups are represented by the formula: alkyl-CO-
5 CH₂- wherein the alkyl group has desirably 1 to 4 carbon
atoms, including acetylmethyl and propionylmethyl etc. The
alkoxycarbonylmethyl groups are represented by the
formula: alkyl-OCO-CH₂- wherein the alkyl group has desir-
ably 1 to 4 carbon atoms, including methoxycarbonylmethyl,
10 ethoxycarbonylmethyl and propoxycarbonylmethyl etc. The
alkylsulfonyl groups are represented by the formula:
alkyl-SO₂- wherein the alkyl group has desirably 1 to 4
carbon atoms, including methylsulfonyl, ethylsulfonyl,
propylsulfonyl and isopropylsulfonyl etc.
- 15 The alkyl groups which may be fluorinated, repre-
sented by R², R³ and R⁴, have desirably 1 to 4 carbon
atoms each. Such unsubstituted alkyl groups include
methyl, ethyl, propyl, isopropyl, butyl and isobutyl etc.
Such fluorinated alkyl groups include trifluoromethyl,
20 2,2,2-trifluoroethyl, 2,2,3,3,3-pentafluoropropyl, 1-
(trifluoromethyl)-2,2,2-trifluoroethyl, 2,2,3,3-tetra-
fluoropropyl and 2,2,3,3,4,4,4-heptafluorobutyl etc.
- The alkoxy groups which may be fluorinated, repre-
sented by R², R³ and R⁴, have desirably 1 to 8 carbon
25 atoms each. Such unsubstituted alkoxy groups include
methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy,
pentoxy, hexyloxy, heptyloxy and octyloxy. Such fluori-
nated alkoxy groups include 2,2,2-trifluoroethoxy,
2,2,3,3,3-pentafluoropropoxy, 1-(trifluoromethyl)-2,2,2-
30 trifluoroethoxy, 2,2,3,3-tetrafluoropropoxy,
2,2,3,3,4,4,4-heptafluorobutoxy and 2,2,3,3,4,4,5,5-octa-
fluoropentoxy.
- In more detail about the compounds (I) and (II), it
is particularly desirable that the ring A is unsubstituted
35 or substituted at the 4- or 5-position with methoxy or
trifluoromethyl, R¹ is a hydrogen atom, R² and R⁴ are

1 independently hydrogen atom or methyl and R^3 is
a fluorinated alkoxy having 2 to 5 carbon atoms.

The vanadium compounds used in this invention include
vanadium pentaoxide (V_2O_5), sodium metavanadate ($NaVO_3$),
5 ammonium metavanadate (NH_4VO_3) and vanadium (IV) acetyl-
acetate $[(CH_3COCH_2COCH_2)_2VO]$, desirably vanadium penta-
oxide, sodium metavanadate and vanadium acetylacetate.

The amount of the vanadium compounds used is
generally about 0.01 to 10 mole%, desirably about 0.05 to
10 2 mole%, particularly desirably about 0.1 to 0.5 mole%
relative to one mole of the compound (I).

Hydrogen peroxide is usually used in an aqueous
solution of hydrogen peroxide, but a solution in an orga-
nic solvent such as n-butylalcohol and a solution in the
15 mixture of said organic solvent and water may also be used.
The concentration of hydrogen peroxide used is usually 10 to
70%, desirably 20 to 40%, but should not be limited only to these ranges.

The amount of hydrogen peroxide used is usually a
slight excess relative to one equivalent of the compound (I),
20 desirably about 1 to 3 equivalents, more desirably about 1
to 1.5 equivalents.

The solvents used for the reaction include haloge-
nated hydrocarbons such as chloroform and dichloromethane,
ethers such as tetrahydrofuran and dioxane, alcohols such
25 as ethanol, methanol and isopropanol, ketones such as
acetone and methylethylketone, nitriles such as aceto-
nitrile and water, among which ethanol, methanol, acetone
and acetonitrile are desirable and ethanol is more desir-
able. These solvents may be used singly or in combi-
30 nation. The amount of the solvent used for the reaction
is about 0.5 to 10 l, desirably about 1 to 5 l, relative to
one mole of the compound (I), but should not be limited only
to these ranges.

The reaction temperature is usually the temperature
35 under ice-cooling to about the boiling point of the sol-
vents, usually the temperature under ice-cooling to about

1 40°C, more desirably about 15 to 30°C.

 The reaction time is usually about 0.5 to 24 hours,
desirably about 1 to 8 hours.

5 The desired compound (II) produced by the reaction
described above is usually separated out as crystals from
the reaction mixture, so that the crystals can be collect-
ed by filtration after decomposition of the excess of
hydrogen peroxide remaining after the reaction by addition
of an aqueous solution of sodium thiosulfate, but the
10 crystals may also be collected by extraction with a sol-
vent such as chloroform if necessary, followed by concentration.

 The crystals thus collected can be purified if neces-
sary by a routine method such as recrystallization and
chromatography.

15 The starting compounds (I) can be produced by the
methods described in, for example, U.S. Patent No.4255431,
European Patent Laid-Open No.45200, No.74341, No.80602,
No.5129, No.174726, No.175464 and Great Britain Patent
Laid-Open No.2134523A, etc.

20 According to the method for production of this invention, 2-(2-
pyridylmethylsulfinyl)benzimidazole can be obtained in a good yield
(about 85% or more) and with low production of by-products such as
2-(2-pyridylmethylsulfonyl) benzimidazole N-oxide.

25 This invention is illustrated in more detail: in the
following Working Examples and Reference Example.

Example 1

2-[[[3-Methyl-4-(2,2,2-trifluoroethoxy)pyrid-2-yl]-
methylthio]benzimidazole (monohydrate) (1.77 g) was dis-
solved in dichloromethane (30 ml), to which was added
30 dropwise at 15-20°C a solution of hydrogen peroxide in t-
butanol (2.75 ml corresponding to 0.2 g of hydrogen per-
oxide) containing vanadium pentaoxide (5 mg), and then
allowed to react at 20-25°C for about one hour. After
completion of the reaction, an aqueous solution of sodium
35 thiosulfate (0.5 g/30 ml) was added to the reaction mix-
ture, which was stirred vigorously for about 10 minutes,
allowed to stand still, and separated into layers. The
dichloromethane layer was washed with water (30 ml), and
concentrated under reduced pressure; to the residue was

1 added a mixture of ethanol-water (9:1, 10 ml) for crystal-
lization. This solution was ice-cooled, and the crystals
were collected by filtration and washed with an ice-cooled
mixture of ethanol-water (8:2). The crystals thus ob-
5 tained were treated with a mixture of ethanol-water (9:1,
10 ml), heated (65-70°C) and stirred for dissolution of the
crystals, then the insoluble matters were removed by hot
filtration. The filtrate was ice-cooled for crystalliza-
tion, and the crystals were collected by filtration,
10 washed with ice-cooled ethanol-water mixture (8:2) and
dried in vacuo to give white crystals of 2-[[3-methyl-4-
(2,2,2-trifluoroethoxy)pyrid-2-yl]methylsulfinyl]benz-
imidazole (1.64 g). (yield: 93.2%).
m.p. 177-178°C (decomposed)

15 Example 2

2-[[3-Methyl-4-(2,2,2-trifluoroethoxy)pyrid-2-yl]-
methylthio]benzimidazole (monohydrate) (10.0 g) was dis-
solved in ethanol (75 ml), to which was added a solution
of sodium metavanadate (15 mg) in 35% aqueous solution of hydrogen
20 peroxide (3.07 g), and allowed to react by stirring at 20-
25° for about 8 hours. After completion of the reaction
an aqueous solution of sodium thiosulfate (1 g/5 ml) was
added to the reaction mixture, which was stirred vigorous-
ly for about 10 minutes. The crystals were collected by
25 filtration and washed with an ice-cooled mixture of etha-
nol-water (1:1). The crystals thus obtained were treated
with a mixture of ethanol-water (9:1, 50 ml), heated (65-
70°C) and stirred so that the crystals were dissolved,
then the insoluble matters were removed by hot filtra-
30 tion. The filtrate was ice-cooled for crystallization,
and the crystals were collected by filtration, washed with
ice-cooled ethanol-water mixture (8:2) and dried in
vacuo, to give white needles of 2-[[3-methyl-4-(2,2,2-
trifluoroethoxy)pyrid-2-yl]methylsulfinyl]benzimidazole
35 (9.0 g). (yield: 90.5%).
m.p. 177-178°C (decomposed)

1 Example 3

2-[[3-Methyl-4-(2,2,2-trifluoroethoxy)pyrid-2-yl]-
methylthio]benzimidazole (monohydrate) (20.0 g) was dis-
solved in ethanol (150 ml), to which was added dropwise at
5 about 20°C a solution of vanadium pentaoxide (30 mg) in a
mixture of 35% aqueous solution of hydrogen peroxide (6.14 g) and
ethanol (6 ml), and allowed to react at 18-22° for about
2.5 hours. After completion of the reaction an aqueous
solution of sodium thiosulfate (2 g/60 ml) was added to
10 the reaction mixture, which was stirred by ice-cooling for
about 1 hour. The crystals were collected by filtration
and washed with an ice-cooled mixture of ethanol-water
(1:1). The crystals thus obtained were treated with a
mixture of ethanol-water (9:1, 100 ml), heated (70-80°C) and
15 stirred so that the crystals were dissolved, then the
insoluble matters were removed by hot filtration. The
filtrate was ice-cooled for crystallization, and the
crystals were collected by filtration, washed with ice-
cooled ethanol-water mixture (8:2) and dried in vacuo,
20 to give white needles of 2-[[3-methyl-4-(2,2,2-trifluoro-
ethoxy)pyrid-2-yl]methylsulfinyl]benzimidazole (17.8 g).
(yield: 89.5%).

m.p. 177-178°C (decomposed)

Example 4

25 Vanadium(IV) acetylacetonate (40 mg) was dissolved in
ethanol (150 ml), to which 2-[[3-methyl-4-(2,2,2-tri-
fluoroethoxy)pyrid-2-yl]methylthio]benzimidazole (monohydrate)
(20.0 g) was added and then 35% aqueous solution of hydrogen
peroxide (6.14 g) was added dropwise at 20-25°C, and
30 the mixture was allowed to react at 20-25°C for about 5
hours. After completion of the reaction, a solution of
sodium thiosulfate (2.7 g/16 ml) was added to the reaction
mixture and stirred vigorously for about 10 minutes. The
crystals were collected by filtration and washed with an
35 ice-cooled mixture of ethanol-water (8:2). The crystals
thus obtained were treated with a mixture of ethanol-water

1 (9:1, 90 ml), heated (60-70°C) and stirred so that the crystals were dissolved, then the insoluble matters were removed by hot filtration. The filtrate was ice-cooled for crystallization and the crystals were collected by
 5 filtration, washed with ice-cooled ethanol-water mixture (8:2) and dried in vacuo, to give white needles of 2-[[3-methyl-4-(2,2,2-trifluoroethoxy)pyrid-2-yl]methylsulfinyl]benzimidazole (18.1 g). (yield: 91.0%).
 m.p. 177-178°C (decomposed)

10 Example 5

Each 2-[[3-methyl-4-(2,2,2-trifluoroethoxy)pyrid-2-yl]methylsulfinyl]benzimidazole obtained in Examples 1-4 and in Reference Example described below was analyzed by high performance liquid chromatography (HPLC)
 15 and the following results were obtained.

Conditions of HPLC

Equipment used: Shimadzu**High Performance Liquid Chromatograph Type LC-6A

20 Detector: Shimadzu Ultraviolet Absorption Photometer Type SPD-6A, measurement wave length: 254 nm

Data processor: Shimadzu Type CR-3A

Column: Nucleosil**5C₁₈ (150 x 40 mm i.d.)

Column temperature: a fixed temperature of about 25°C

25 Mobile phase: A mixture of methanol-water-triethylamine (60:40:1) of which pH has been adjusted to 7.0 by addition of phosphoric acid.

Flow rate: 0.7 ml/min.

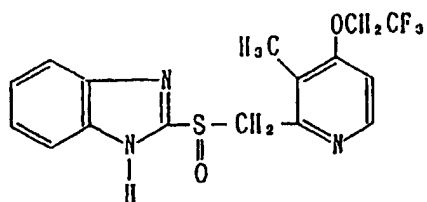
Time required for analysis: 30 minutes

30	Compound	Area percentage (%) in high performance liquid chromatography				
		Exam- ple 1	Exam- ple 2	Exam- ple 3	Exam- ple 4	Reference Example
	sulfoxide derivative*1)	99.3	99.6	99.6	99.7	98.9
35	N-oxide derivative*2)	0.1	<0.1	<0.1	<0.1	0.6

**Trademark

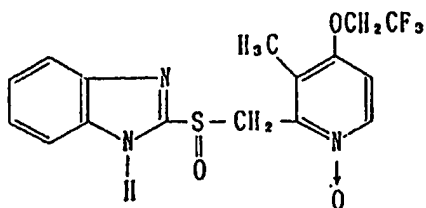
1 *1)

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*2)

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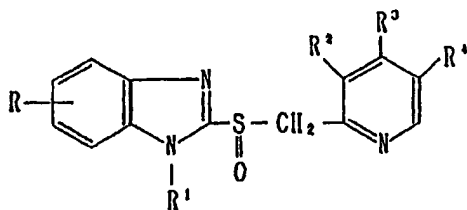


15 Example 6

According to the same method as in Example 4,
the following compounds were produced and analyzed by HPLC
under the same conditions as in Example 5; the
results are summarized as follows.

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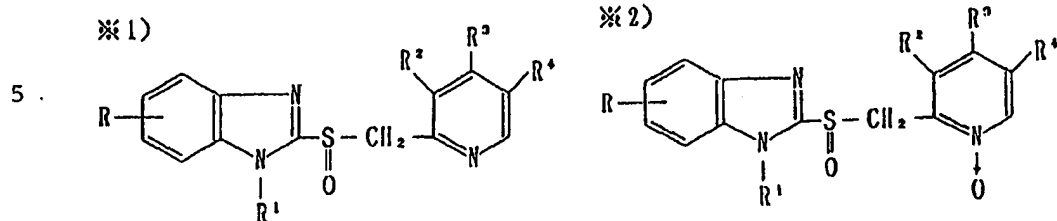
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No	R	R ¹	R ²	R ³	R ⁴	m.p. yield		Area percentage(%) in HPLC	
						(°C)	(%)	sulfoxide*1)	N-oxide*2)
1	H	H	CH ₃	OCH ₂ CF ₃	CH ₃	177~178(d) [※]	89	99.6	<0.1
1	5-CF ₃	H	H	OCH(CH ₃) ₂	H	154~155(d)	87	99.6	<0.1
1	5-CF ₃	H	H	OCH ₃	H	165~166(d)	88	99.7	<0.1
1	4-CF ₃	H	H	OCH ₃	H	150~151(d)	86	99.5	0.1
1	5-OCH ₃	H	CH ₃	OCH ₃	CH ₃	155~156(d)	87	99.7	<0.1
1	5-CH ₃	H	CH ₃	OCH ₃	CH ₃	180~181(d)	88	99.7	<0.1
1	H	CH ₂ OOCH ₃	CH ₃	OCH ₃	CH ₃	131~133	85	99.6	0.1
1	5-F	H	H	OCH(CH ₃) ₂	H	145~147(d)			
2	5-OCF ₃	H	CH ₃	OCH ₃	H	184~185(d)			
	6-OCF ₃								



10 ※)decomposition

15 Reference Example

2-[[3-Methyl-4-(2,2,2-trifluoroethoxy)pyrid-2-yl]methylthio]benzimidazole (monohydrate) (20 g) was dissolved in chloroform (200 ml), to which was added slowly dropwise below 5°C a solution of m-chloroperbenzoic acid (13.5 g) in chloroform (200 ml), and stirred at the same temperature for about 10 minutes. After completion of the reaction, the reaction mixture was washed with a solution of sodium hydrogencarbonate, and dried over magnesium sulfate, and chloroform was evaporated off under reduced pressure. To the residue was added ethanol (100 ml) for crystallization, which was ice-cooled; the resulting crystals were collected by filtration and washed with ice-cooled ethanol. The crystals thus obtained were treated with a mixture of ethanol-water (9:1, 90 ml), heated (65-70°C) and stirred so that the crystals were dissolved, then the insoluble matters were removed by hot filtration. The filtrate was ice-cooled for crystallization and the crystals were collected by filtration, washed with ice-cooled ethanol-water mixture (8:2), and dried in vacuo, to give white needles of 2-[[3-methyl-4-(2,2,2-trifluoroethoxy)pyrid-2-yl]methylsulfinyl]benz-

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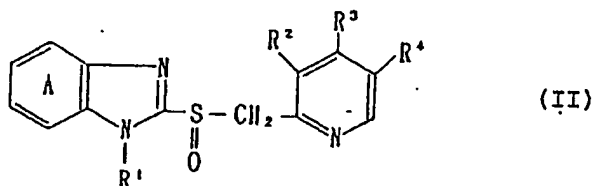
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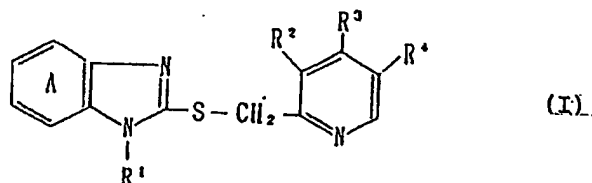
- 1 imidazole (14.9 g, yield: 74.9%).
m.p. 177-178°C (decomposed)

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method for producing a compound having the formula:



(wherein the ring A may be substituted; R^1 is a hydrogen atom or an N-protective group; R^2 , R^3 and R^4 are independently hydrogen atom, an alkyl group which may be fluorinated or an alkoxy group which may be fluorinated), which comprises subjecting a compound having the formula



(wherein A, R^1 , R^2 , R^3 and R^4 are the same as described above), to oxidation with hydrogen peroxide in the presence of a vanadium compound.

2. A method according to claim 1, wherein the substituent of the ring A is C_{1-7} alkyl, halogen, cyano, carboxy, carbo- C_{1-4} alkoxy, carbo- C_{1-4} alkoxy- C_{1-4} alkyl, carbamoyl, carbamoyl- C_{1-4} alkyl, hydroxy, C_{1-5} alkoxy, hydroxy- C_{1-7} alkyl, trifluoromethyl, C_{1-4} acyl, carbamoyl-oxy, nitro, C_{1-4} acyl-oxy, aryl, aryloxy, C_{1-4} alkyl-thio or C_{1-6} alkyl-sulfinyl.

3. A method according to claim 1, wherein the N-protective group is C_{1-5} alkyl, C_{1-4} acyl, carbo- C_{1-4} alkoxy, carbamoyl, C_{1-4} alkyl-carbamoyl, di- $(C_{1-4}$ alkyl)-carbamoyl, C_{1-4} alkyl-carbonylmethyl, C_{1-4} alkoxy-

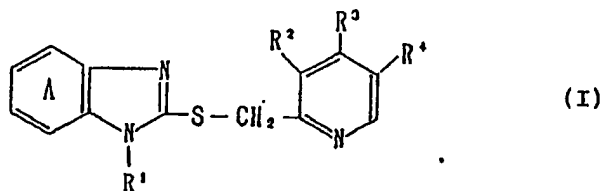
carbonylmethyl or C₁₋₄ alkyl-sulfonyl.

4. A method according to claim 1, wherein R², R³ and R⁴ are independently C₁₋₄ alkyl which may be fluorinated or C₁₋₈ alkoxy which may be fluorinated.

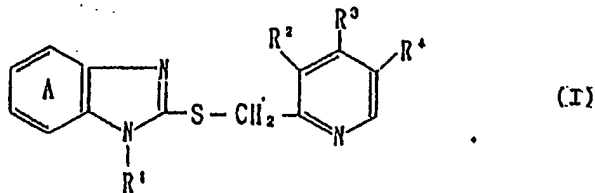
5. A method according to claim 1, wherein the ring A is unsubstituted or substituted at the 4- or 5-position with methoxy or trifluoromethyl, R¹ is hydrogen, R² and R⁴ are independently hydrogen or methyl and R³ is a fluorinated C₂₋₅ alkoxy.

6. A method according to claim 1, wherein the vanadium compound is vanadium pentaoxide, sodium metavanadate, ammonium metavanadate or vanadium (IV) acetylacetonate.

7. A method according to claim 1, wherein the vanadium compound is used in an amount of about 0.01 to 10 mole % relative to the compound having the formula:



8. A method according to claim 1, wherein hydrogen peroxide is used in an amount of about 1 to 3 equivalents relative to the compound having the formula:



9. A method according to claim 2 or 3, wherein R^2 , R^3 and R^4 are independently C_{1-4} alkyl which may be fluorinated or C_{1-8} alkoxy which may be fluorinated.

10. A method according to claim 2, 3 or 4, wherein the ring A is unsubstituted or substituted at the 4- or 5-position with methoxy or trifluoromethyl, R^1 is hydrogen, R^2 and R^4 are independently hydrogen or methyl and R^3 is a fluorinated C_{2-5} alkoxy.

11. A method according to claim 5, 7 or 8, wherein the vanadium compound is vanadium pentaoxide, sodium metavanadate, ammonium metavanadate or vanadium (IV) acetylacetonate.

12. A method according to claim 2, 3 or 5, wherein the vanadium compound is vanadium pentaoxide, sodium metavanadate, ammonium metavanadate or vanadium (IV) acetylacetonate; the vanadium compound is used in an amount of about 0.01 to 10 mole % relative to the compound of the formula (I); and hydrogen peroxide is used in an amount of about 1 to 3 equivalents relative to the compound of the formula (I).

13. A method according to claim 2, 3 or 5, wherein the vanadium compound is vanadium pentaoxide, sodium metavanadate, ammonium metavanadate or vanadium (IV) acetylacetonate; the vanadium compound is used in an amount of about 0.05 to 2 mole % relative to the compound of the formula (I); hydrogen peroxide is used in an amount of about 1 to 3 equivalents relative to the compound of the formula (I) using a solvent selected from the class consisting of halogenated hydrocarbon solvents, ether solvents,

alcohol solvents, ketone solvents, nitrile solvents, water and mixtures thereof; and the oxidation reaction is carried out at an ice-cooling temperature to about 40°C.

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PATENT AGENTS

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